PAMPRE and the Chemistry of Neutral Species in Titan's Upper Atmosphere

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[1] Abstract

A complex atmospheric photochemistry has been revealed in Titan's atmosphere by the ongoing Cassini-Huygens mission. Its composition mainly made out of N_2-CH_4 leads to ionization and photo-dissociative processes that eventually form solid organic aerosols called tholins. Tholins are assumed to be formed in the ionosphere, where they coexist with the gas phase, in an ionic and neutral medium. The PAMPRE set-up aims at simulating the reactivity and production of solid aerosols in Titan's ionospheric conditions through heterogeneous chemistry in a radiofrequency-induced plasma.
In this study, our aim was to accumulate gas products in an N_2-CH_4 (90-10%) mixture using a cold trap to retain the products. These were then released after end of cooling and analyzed with infrared spectroscopy and mass spectrometry in order to better understand the chemical reactivity at work.

[2] Introduction

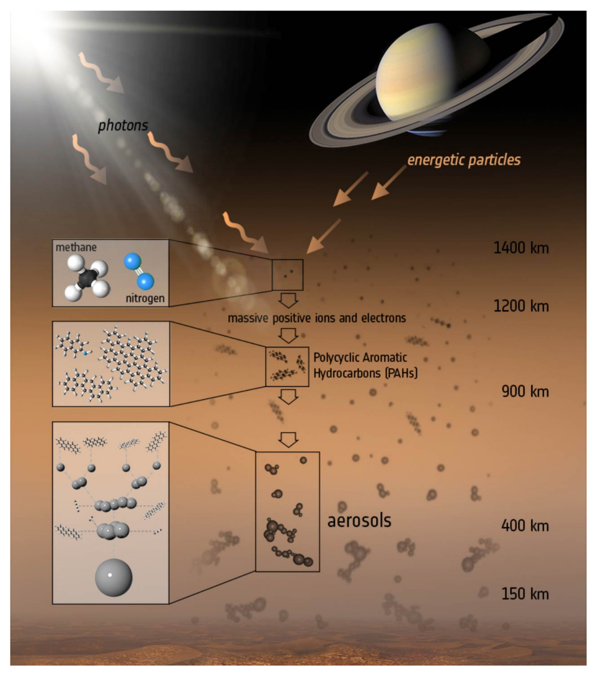


Fig. 1. The intense photochemistry leading up to the formation of aerosols that make up the hazy layers on Titan. Image credit: ESA/ATG medialab

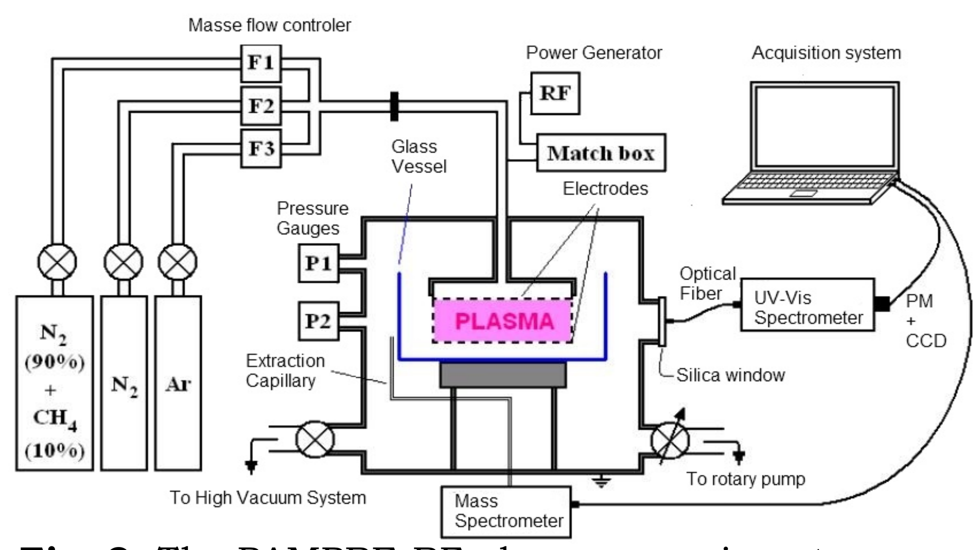


Fig. 2. The PAMPRE RF plasma experiment (Szopa et al., 2006)

[3] The experiment

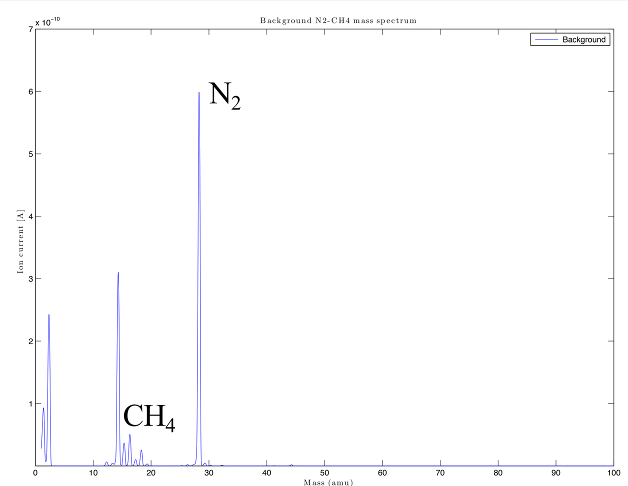


Fig. 3. Background mass spectrum

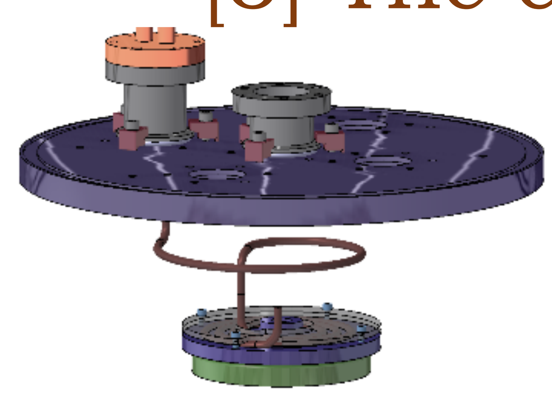


Fig. 4. The cryogenic trap system

- The cryogenic trap was set at a temperature of T°= 100 K in order to try and trap as many products as possible

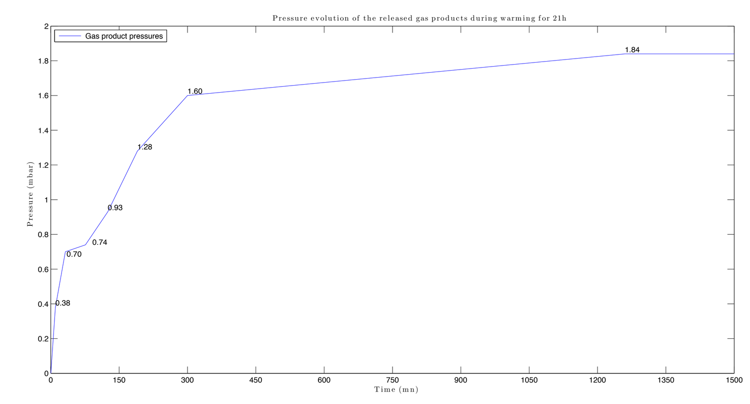


Fig. 5. Pressure evolution of the gas products released after end of cooling

[4] Infrared Spectroscopy

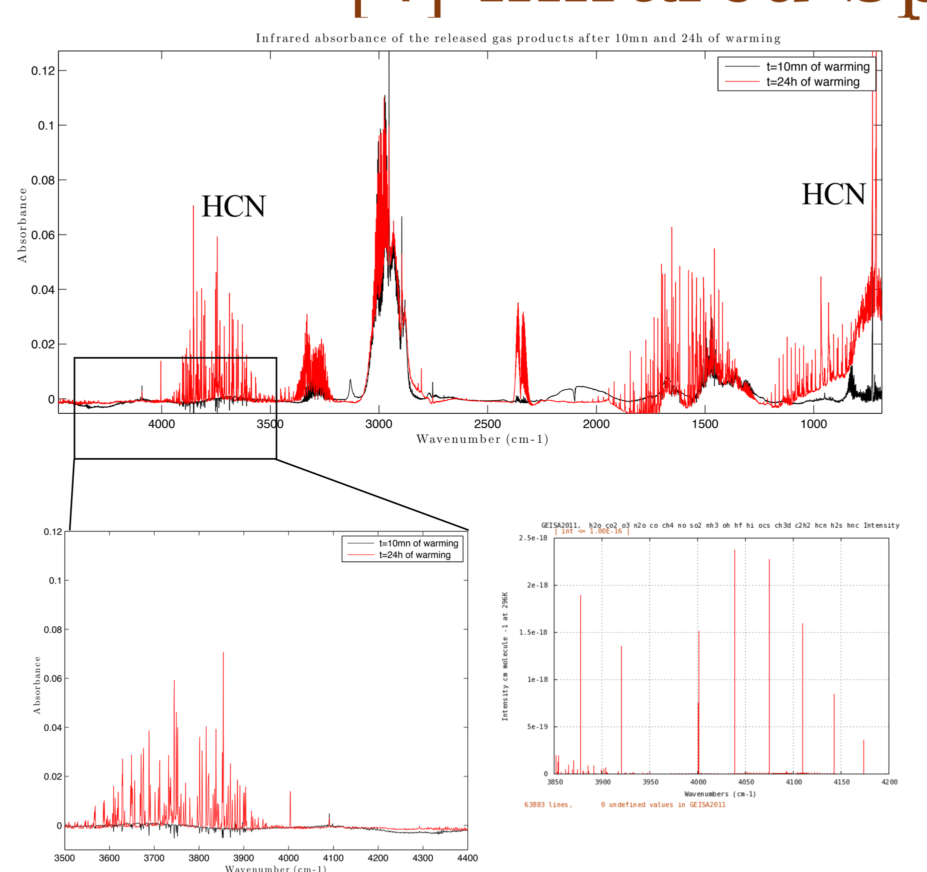


Fig. 6. Infrared absorption of the gas products released after cryogenic trap, with zoom centered at 4000 cm^{-1}, compared with the GEISA spectroscopy database

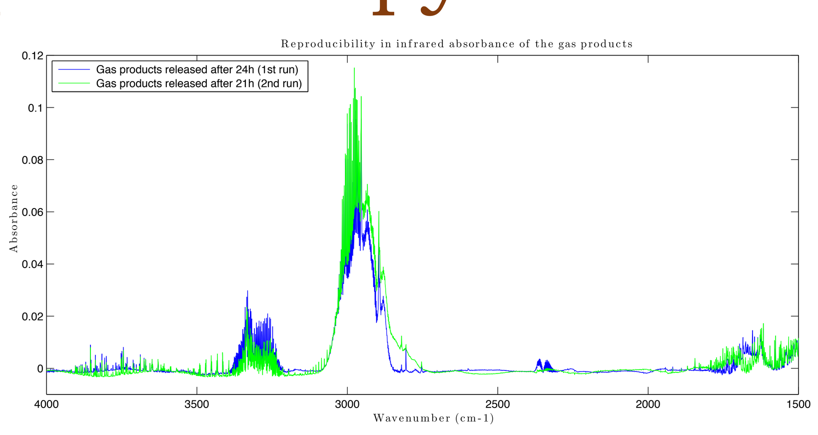


Fig. 7. Test of reproducibility

[5] Mass Spectrometry

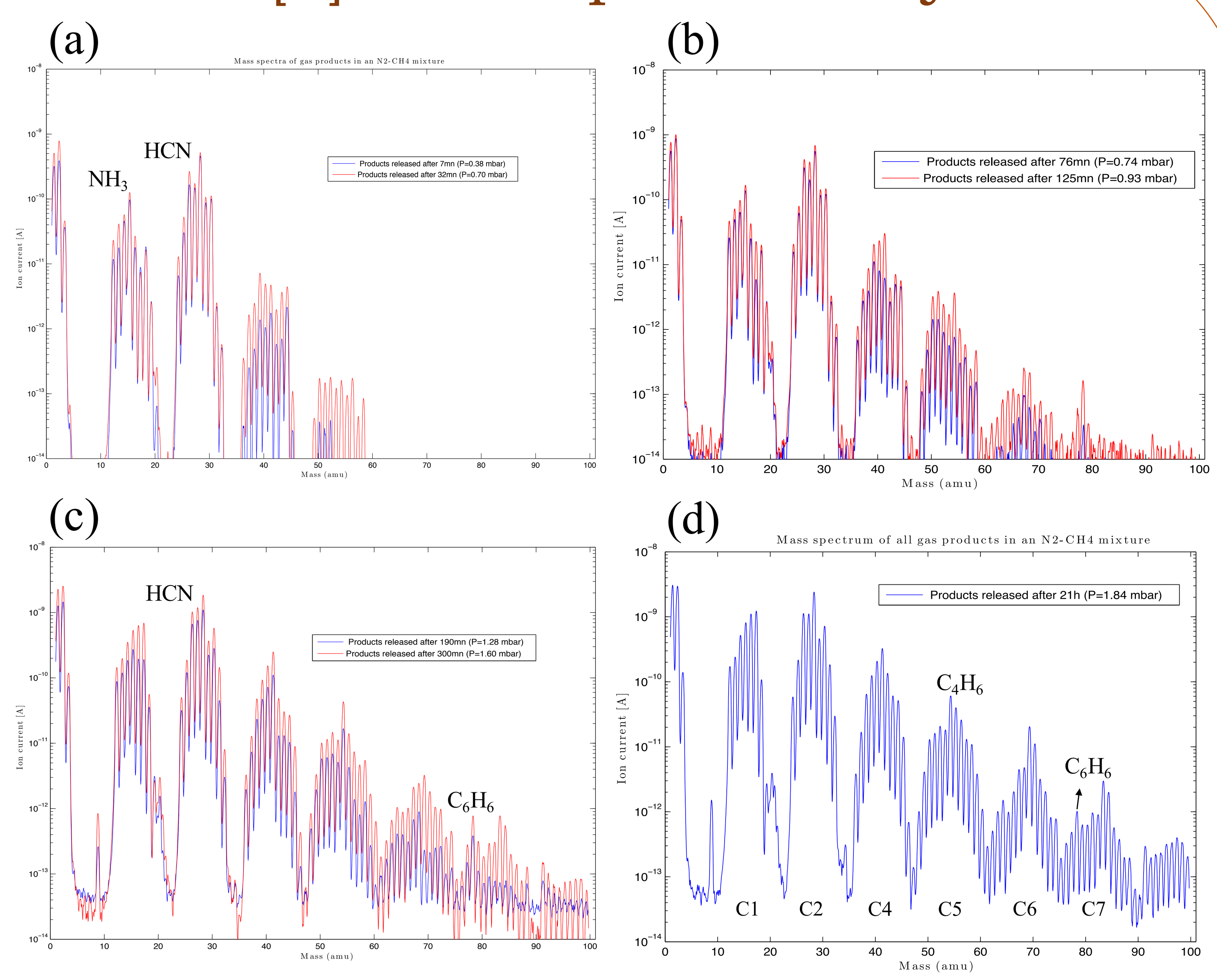
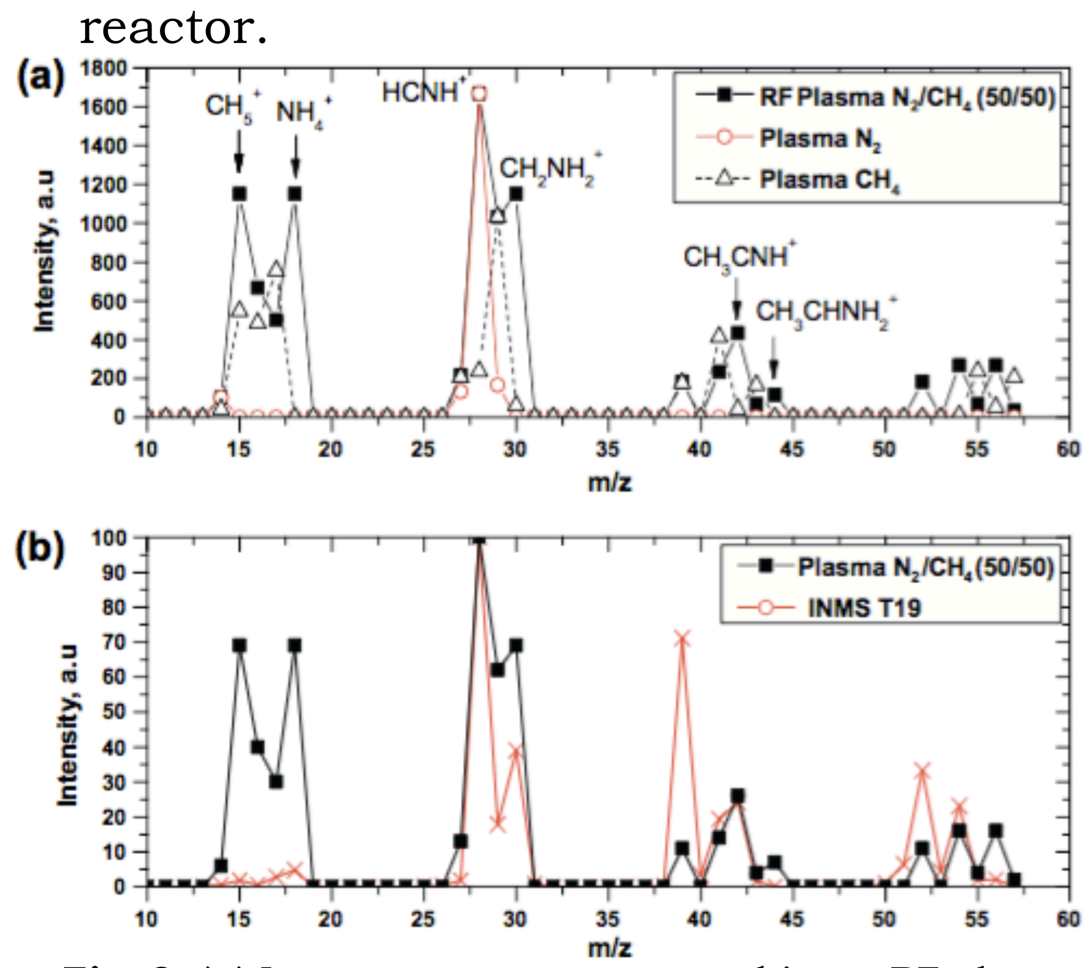


Fig. 8. Gas products released after 32mn (a), 125mn (b), 300mn (c) and 21h (d). The final pressure of gas products attained here is 1.84 mbar. For the first 32mn, C1 and C2 molecules are already well present. C3 and C4 compounds appear after 76mn. C5, C6 and higher mass molecules are detectable back at room temperature, at the end of our experiment.

[6] Perspectives

- In light of this study of neutral species, the next step will be to analyze positive and negative ions by secondary ion mass spectrometry coupled with the reactor.



- Data provided by the INMS instrument onboard Cassini showed the prevalence of ion chemistry leading to the formation of the tholins (Mandt et al., 2012).

Fig. 9. (a) Ion mass spectra measured in an RF plasma (adapted from Mutsukura, 2001)
(b) Qualitative comparison of positive ions in an RF plasma and in Titan's ionosphere (Carrasco et al., 2012)

References

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